THE OPTIC THALAMUS.*

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THE fibres of the "tegmentum cruris" are connected with the following ganglia: the "*optic thalamus*"; the "*corpus quadrigeminum*"; the "*corpus mamillare*"; the "*pineal gland*" (conarium); and a *ganglion embedded in the crural sling*. The two ganglia first named have a connection with the optic tract, in addition to a connection with the spinal cord. For this reason, the "corpora geniculata" may be considered as an appendage to them.

Let us consider, before the other ganglia are touched upon, the peculiarities in arrangement of the optic thalamus and its probable functions.

This ganglion appears, at first glance, to present its gray matter, exposed and uncovered, as a lining to the third ventricle. In this region, a band of white fibres, the "*stratum zonale*," defines its limits and separates it from the tail-like projection of the corpus striatum. When the gray lining of the ventricle is examined, however, it becomes evident that it is structurally independent of the optic thalamus, because it can be traced as a direct continuation of the central tubular gray matter. It is in reality foreign to

* A lecture delivered before the students of the Medical Department of the University of the City of New York.

the thalamus. It will be described, in detail, later in the course.

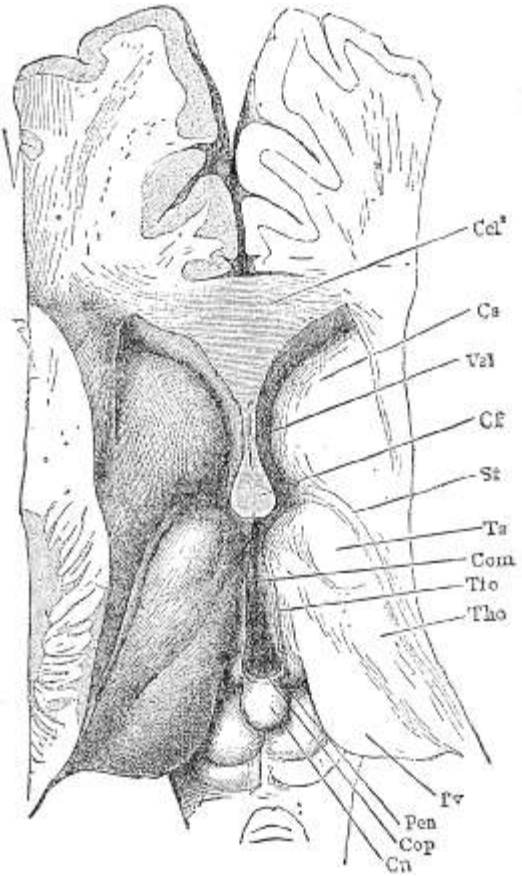

FIG. 1.—VIEW FROM ABOVE OF THE THIRD VENTRICLE AND A PART OF THE LATERAL VENTRICLES. (Henle.) The brain has been sliced horizontally, immediately below the corpus callosum, and the fornix and velum interpositum have been removed. *Tho*, thalamus opticus; *Ts*, its anterior tubercle; *Pv*, pulvinar; *Com*, middle commissure stretching between the two optic thalami across the middle of the third ventricle; *Cf*, columns of the fornix; *Cn*, pineal gland projecting downward and backward between the superior corpora quadrigemina; *Sf*, stria terminalis; *Cs*, nucleus caudatus of the corpus striatum; *Vsl*, ventricle of the septum lucidum; *Ccl²*, section of the genu of the corpus callosum; *Pen*, commencement of the pineal stria or peduncle, *Tfo*; *Cop*, posterior commissure.

The optic thalamus, as well as the corpus quadrigeminum, is poorly developed in the human brain, when compared with that of the lower animals. In shape, it has been compared by Meynert to "an arch surrounding a transverse

axis"; in which respect it bears an analogy to the caudate nucleus of the corpus striatum, and the general arrangement of the cerebral lobes. The axes, around which the thalamus appears to arch, comprise the brachia of the corpus quadrigeminum and the corpus geniculatum internum. The greatest breadth of the thalamus lies posterior to the axis; the greatest thickness is found just in front of the axis; and, at its anterior extremity, the breadth and thickness attain their minimum.

If the fornix and velum interpositum be removed and the optic thalami viewed from above, they appear as oval-shaped masses of gray substance covered superficially by a thin layer of white fibres. A longitudinal groove may be detected on the superior surface of each, which inclines slightly inward so that its anterior extremity approaches the mesial plane. It terminates before the anterior extremity of the thalamus is reached. This groove is caused by the thickened margin of the fornix, which extends over the surface of the thalamus along the line of the groove. The anterior part of the thalamus is raised into a prominence, the so-called "*anterior tubercle*," which projects into the lateral ventricle and is covered with the epithelial lining of that cavity. It lies above a part of the lenticular nucleus, as may be seen in all cross-sections of the cerebrum.[1] At the posterior and inner part of the thalamus, is seen, as in front, a posterior prominence or tubercle, the "*pulvinar*." This projects over, and partly conceals, the brachia of the corpus quadrigeminum. Below and external to the pulvinar, another well-marked eminence, the "*outer geniculate body*," may be seen, which lies external to, and above the "*inner geniculate body*." These two eminences are separated by one of the roots of the optic tract (upper brachium). The

[1] The anterior tubercle is farther removed from the level of the base of the cerebrum than any other part of the thalamus.

optic tract arises from this brachium and the two geniculate bodies, and curves downward and forward around the crus cerebri.

Such being the general direction and shape of the thalamus, we are prepared to consider the arrangement of the fibres which are connected with it. It presents, in the first place, three blunt pedicles, which become united with some of the fibres of the superior projection system (*corona radiata*). Those fibres which become ultimately united with these blunt processes, may be traced to the cortex of the frontal lobe, and that of the walls of the Sylvian fossa, and of the temporal sphenoidal lobe. The ganglion is also in intimate relation with fibres which radiate to the cortex of the occipital and parietal lobes.

The external and inferior surfaces of the thalamus are not free, but are united by means of fibres with other parts of the brain. The external surface lies in close relation with fibres of the "crusta," which pass between the lenticular nucleus and the thalamus—those forming the "internal capsule" of the cerebrum. The inferior surface is in relation with the crus; and, more anteriorly, the corpus albicans and the tuber cinereum lie below it.

The *outlines of the surfaces* of the thalamus and the lenticular nucleus of the corpus striatum, as seen in all cross-sections of the cerebrum, may be roughly compared to the form of a square whose two halves are defined by a diagonal band, the "internal capsule,"[1] running from the upper and outer corner to the lower and inner corner. These halves correspond to the respective ganglia. It may be worthy of remark, in this connection, that the surface of the thalamus which lies in contact with the internal capsule of the cerebrum marks the central or receiving pole for the

[1] This bundle of fibres ceases with the posterior limits of the *lenticular nucleus* of the corpus striatum.

fibres which join it with the cortex of the cerebral lobes. This is not the case with the lenticular nucleus, as has been stated in a previous lecture.[1]

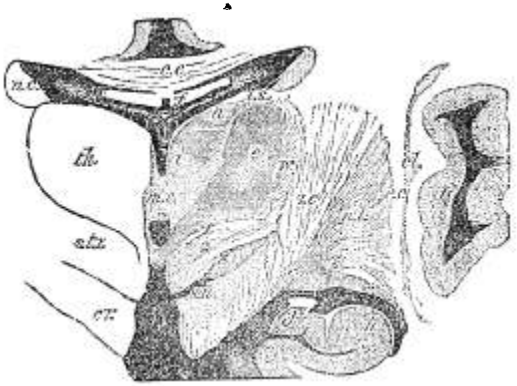

FIG. 2.—SECTION ACROSS THE OPTIC THALAMUS AND CORPUS STRIATUM IN THE REGION OF THE MIDDLE COMMISSURE. (Schäfer after a preparation by Mr. S. G. Shattuck.) Natural size. *th.*, thalamus; *a*, *e*, *i*, its anterior, external, and internal nuclei respectively; *w*, its latticed layer; *m. c.*, middle commissure; above and below it is the cavity of the third ventricle; *c. c.*, corpus callosum; *f*, fornix, separated from the third ventricle and thalamus by the velum interpositum. In the middle of this are seen the two veins of Galen and the choroid plexuses of the third ventricle; and at its edges the choroid plexuses of the lateral ventricles; *t. s.*, tænia semicircularis; *cr*, forward prolongation of the crusta passing laterally into the internal capsule, *i. c.*; *s. t. r.*, subthalmic prolongation of the tegmentum, consisting of (1) the dorsal layer, (2) the zona incerta, and (3) the corpus subthalamicum; *s. n.*, substantia nigra; *n. c.*, nucleus caudatus of the corpus striatum; *n. l.*, nucleus lenticularis; *e. c.*, external capsule; *cl*, claustrum; *I*, Island of Reil.

The *external surface* of the thalamus (which lies in contact with the internal capsule of the cerebrum) presents a peculiar appearance, which has given it the name of "lattice layer" (Kölliker). All along this surface, radiating fibres pass out of the thalamus to become intermingled with the fibres of the internal capsule, and to be distributed to the cerebral cortex. Those from the front of the ganglion pass to the frontal lobe; those from the middle are distributed to the posterior part of the frontal and to the parietal and temporo-sphenoidal lobes; those from the posterior part can be traced to the temporo-sphenoidal and occipital lobes. From the region of the pulvinar, or posterior tubercle, fibres can be traced into the optic tract.

[1] "The Corpus Striatum," JOURNAL OF NERVOUS AND MENTAL DISEASE, Jan., 1883.

The *lower surface* of the thalamus is continuous, posteriorly, with the fibres of tegmentum cruris (the *sub-thalmic tegmental region*); in front, however, this prolongation of fibres inclines to the outer side of the ganglion and becomes lost in a layer of gray matter seen in the floor of the ventricle, which corresponds to the anterior perforated lamina of the base of the brain.

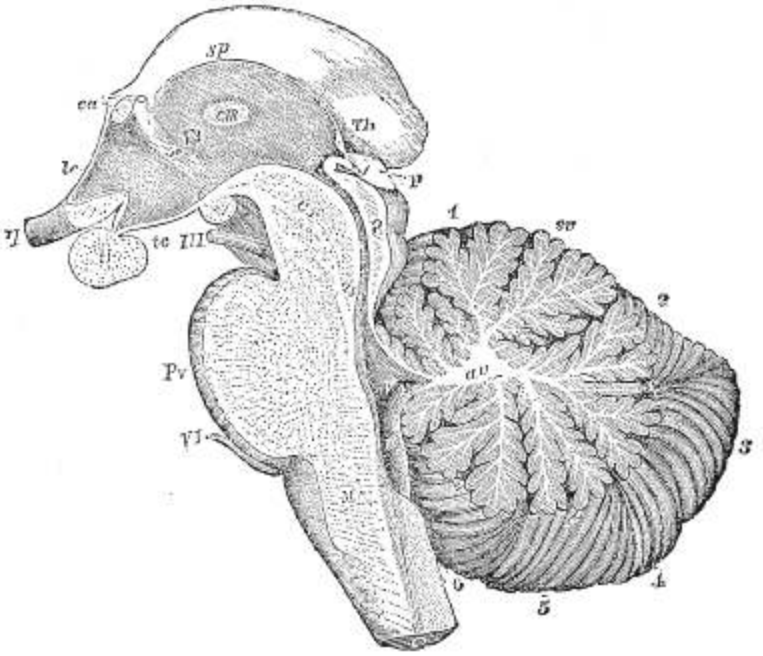

FIG. 3.—RIGHT HALF OF THE ENCEPHALIC PEDUNCLE AND CEREBELLUM AS SEEN FROM THE INSIDE OF A MEDIAN SECTION. (Allen Thomson after Reichert.) II, right optic nerve; behind it the optic commissure divided; III, right third nerve; VI, sixth nerve; V^3, third ventricle; *Th*, back part of the thalamus opticus; *H*, section of the pituitary body; *p*, pineal gland; below its stalk is the posterior commissure; *ca*, anterior commissure divided, and behind it the divided anterior pillar of the fornix; *lc*, lamina cinerea; *i*, infundibulum (cavity); *tc*, tuber cinereum; behind it the corpus albicans; *f*, mark of the anterior pillar of the fornix descending in the wall of the third ventricle; *cm*, commissura mollis; *sp*, stria pinealis, or peduncle of pineol gland; *Q*, lamina quadrigemina; *as*, aqueduct of Sylvius near the fourth ventricle; *cr*, crus cerebri; *Pv*, pons varolii; *M*, medulla oblongata; and behind these the cerebellum.

The lower surface of the thalamus is itself prolonged, anteriorly, into a tract of fibres which run downward and outward into the white substance of the cerebral hemi-

sphere, forming the so-called "*lower peduncle of the thalamus.*"[1] A bundle of fibres, the "ansa lenticularis," passes underneath the thalamus and above the lower peduncle of that ganglion from the mesial part of the crusta to the lenticular nucleus. Between these two tracts of fibres gray matter is interposed; the three, collectively considered, being called the "*substantia innominata of Reil.*"

The substance of the thalamus consists of nerve-fibres and nerve-cells, variously disposed; but the exact arrangement of each, and the connections of the nerve-cells with special fibres, is a subject for much future investigation. Many of the theories advanced will be discussed later.

The thalami approach each other very closely in the median line; and, slightly forward of the middle of the third ventricle, are actually joined by a band of gray matter, the so-called "*middle*" or "*soft commissure*" of the thalamus (see fig. 1). This is sometimes double, and occasionally is absent. It is often torn across in removing the brain. This connecting band is composed entirely of gray matter. Not more than one half of the actual antero-posterior measurement of the thalamus is exposed in the third ventricle. It must be noted that the anterior tubercle appears in the lateral ventricle; and that the pulvinar, or posterior tubercle, lies in a plane posterior to that which would intersect the corpora quadrigemina. Note also that the anterior commissure of the third ventricle does not connect the optic thalami, or have any structural relation with them. The posterior commissure is a continuation of the commissural fibres of the fillet (*lemniscus*), which pass through the substance of the optic thalami and diverge in the cerebral hemispheres. These fibres may, in part, act as commissural fibres between the thalami.

[1] Meynert claims that these fibres arise from the cortex of the fossa of Sylvius and the temporo-sphenoidal lobe.

The nerve-fibres, which may be enumerated as intimately associated with the structures of the thalamus, can be divided into sets, as follows:

1. Fibres of the *superior projection system*, which serve to unite the thalamus with the cortex of the frontal, parietal, occipital, and temporo-sphenoidal lobes, and the fossa of Sylvius.

2. Certain fibres which can be traced directly into the *optic tract*, thus proving some functional relationship between the thalamus and the retina.

3. Fibres of the *tegmentum cruris*, which connect the thalamus with the sensory tract of the spinal cord. As stated in a previous lecture, these are to be classed as fibres of the middle projection system (Meynert).

4. It is claimed by Luys that the *anterior tubercle* of the thalamus can be proved to be directly connected with special fibres which lead to regions of the cortex functionally related with the *olfactory sense.*

5. There is strong clinical evidence to be adduced in support of the view that the *sense of hearing* is, in some imperfectly understood way, connected with the thalamus.

Efforts have been made by some of the later anatomists, who have specially investigated the brain, to subdivide the gray matter of the thalamus into circumscribed masses or nuclei, and to trace the fibres which appear to arise from these nuclei to special regions of the brain and spinal cord. Among the most attractive of these attempts may be mentioned that of Luys, whose views will be subsequently given in detail. Whether clinical research and physiological experiment will confirm all of these attractive theories, and place them upon a ground as worthy of credence as the deductions of Broca and Ferrier regarding the functional attributes of other parts of the brain, time alone can decide.

According to the researches of Luys, four isolated ganglions may be demonstrated in the thalamus. Arnold, in common with some other anatomists, has recognized three of these, and the fourth is now added by the author quoted. This author states that these ganglia are arranged in an antero-posterior plane, and form successive tuberosities upon the thalamus, giving that body the appearance of a conglomerate gland.

The anterior ganglion (*corpus album subrotundum*) is especially prominent. It appears to be developed in animals in proportion to the acuteness of the sense of smell. By means of the "tænia semicircularis," this ganglion (according to the author) may be shown, in the human species, to be connected with the roots of the olfactory nerve. Respecting it he says: "Direct anatomical examination shows that there are intimate connections between the anterior centre and the peripheral olfactory apparatus. On the other hand, in confirmation of this, in the animal species, in which the olfactory apparatus is very much developed, this ganglion itself is proportionally very well marked. Analogy has thus led us to conclude that this ganglion is in direct connection with the olfactory impressions, and that this marks it as the point of concentration toward which they converge before being radiated toward the cortical periphery."

The *second or middle centre* is in apparent continuity with the fibres of the optic tract. It may therefore be considered, on the same grounds as those previously quoted respecting the anterior centre, as a seat of condensation and radiation of visual impressions.[1] There seem to be undisputable grounds for the belief that the geniculate bodies, the corpora quadrigemina, and the angular gyrus of the

[1] Luys states that it is scarcely visible in those animals (the mole as an example) where the optic nerves are rudimentary.

parietal lobe are, in some way, also associated with the perceptions afforded by the retina. Possibly, moreover, the occipital lobes may be added to the ones previously mentioned, since physiological experiment tends toward that view. Ritti has pointed out that irritation of the thalamus may play an important part in the development of hallucinations. We know that extirpation of the eye is followed by more or less complete atrophy of the outer geniculate body of the opposite side, although the inner geniculate body seems to remain unaffected. The experiments of Longet, who destroyed the optic thalami upon both sides without being able to note any impairment of vision or influence upon the movements of the pupil; and those of Lussana and Lemoigne, who found that blindness of the opposite eye followed unilateral destruction of the thalamus, may suggest the possibility, in the former, of the escape of this centre and, in the latter, its destruction. It is difficult to devise any experiment which will positively settle the bearings of the thalamus upon vision; because it is almost impossible to destroy special portions with accuracy, or if this were ensured, to avoid injury to adjacent structures. Fournié claims to have effected the separate annihilation of the special senses of smell and vision by injections made into different parts of the thalamus of animals; and his experiments, if subsequently verified, will tend to confirm some of the theories advanced by Luys.

The *third centre* ("median ganglion" of Luys) is described as about the size of a pea, and situated mathematically in the exact centre of the thalamus. To it the discoverer ascribes the function of presiding over and condensing all *sensory impressions*.

The *fourth posterior centre* is stated to act as a halting place and condenser of *auditory impressions*. Two instances

where the brains of deaf-mutes were found to present a localized lesion of this centre are reported by Luys.

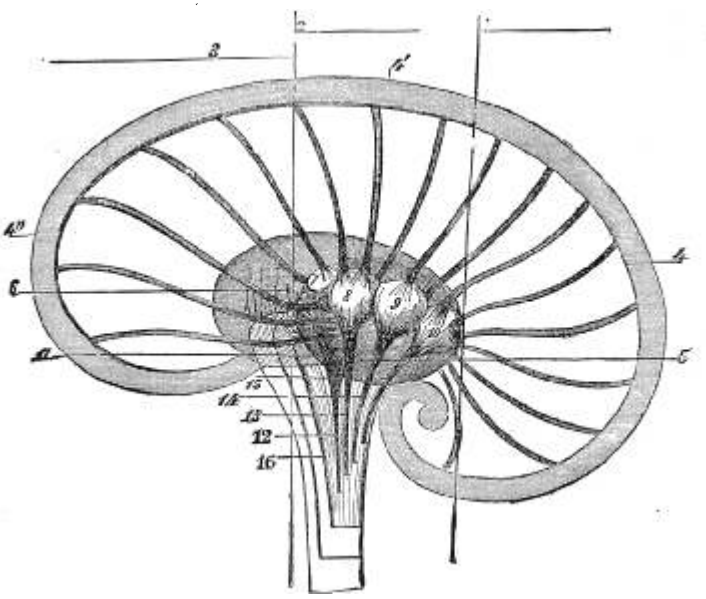

FIG. 4.—A DIAGRAM OF THE NUCLEI OF THE OPTIC THALAMUS AND THE CONVERGING FIBRES ASSOCIATED WITH THEM. (Luys) 1, Converging fibres of posterior convolutions; 2, Same, of middle convolutions; 3, Same, of posterior convolutions; 4, 4', 4'', Cortical periphery as related to the central gray masses; 5, Optic thalamus; 6, Corpus striatum; 7, Anterior (*olfactory*) centre; 8, Middle (*optic*) centre; 9, Median (*sensitive*) centre; 10, Posterior (*acoustic*) centre; 11, Central gray region; 12, Ascending gray fibres of visceral innervation; 13, Gray optic fibres; 14, Ascending sensitive fibres; 15, Ascending acoustic fibres; 16, Series of antero-lateral fibres of the spinal axis going to be lost in the corpus striatum.

The views here expressed are quoted on account of their originality; and the author of them ranks high as an authority upon the subject of which he speaks. The numerous cases of cerebral hemorrhage which have been reported, where the thalamus was apparently the seat of localized injury, are too often accompanied with a clinical history which points toward pressure upon the internal capsule to be of value as confirmatory evidence of the existence of special centres in the thalamus. The effort of Luys to adduce cases of hemianæsthesia in support of his views regarding the function of the "median centre" of

the thalamus, merely because a lesion of that ganglion was found in an area defined by him as the normal limits of that special centre, must not be deemed conclusive; because the same effect *might* have been produced by pressure upon the *posterior third* of the internal capsule of the cerebrum. There is every reason to hope and possibly to believe that sooner or later isolated ganglia within the optic thalamus will be demonstrated to exist by normal and pathological anatomy as well as by physiological experiment; but the conclusions even of so prominent an author should not be fully accepted without further testimony to substantiate their accuracy.

Some interesting cases have, however, already been brought forward, which certainly seem to sustain the views advanced. A case reported by Hunter,[1] where a young woman successively lost the senses of smell, sight, sensation, and hearing, and who gradually sank, remaining a stranger to all external impressions, disclosed at the autopsy a fungus hæmatodes which had gradually destroyed the optic thalamus of each side, and the optic thalami alone, if the drawing given is reliable. Again, Fournié's experiments on living animals point strongly to the existence of localized centres in the thalamus. Three instances of unilateral destruction of smell, observed by Voisin and reported by Luys, have been found to be associated with a destruction of the anterior centre of the thalamus. A hemorrhagic effusion into the thalamus, on a level with the soft commissure (the situation of the optic centre of Luys'), produced (in the experience of Serres) a sudden loss of sight in both eyes. Ritti's paper upon the effects of irritation of the thalamus upon the development of hallucinations, lends strength to the view that that ganglion in some way regulates the transmission of sensory impressions of all kinds to

[1] Medico-chirg. Trans., London, 1825, vol. xiii.

the cerebral cortex; and confirms the opinion that "the optic thalami are to be regarded as intermediary regions which are interposed between the purely reflex phenomena of the spinal cord and the activities of psychical life."

The view taken by Lussana and Lemoigne, that the optic thalami contained motor centres in animals for the lateral movements of the forelimbs of the opposite side, seems to be completely overthrown by pathological statistics in the human race. The results obtained by these experimenters are also at variance with the belief, which has now become general among neurologists, that the thalami are intimately connected with the sensory tracts of the cerebrum and cord; since they concluded that no evidence of pain or any loss of sensibility resulted from injury to these bodies.

The effects of all experiments on animals, however, agree entirely with the general experience of pathologists, that lesions of both the thalamus and corpus striatum produce results upon the opposite side of the body; whether the symptoms produced point to a disturbance of the kinesodic (motor) or æsthesodic (sensory) tracts. The view originally advanced by Carpenter and Todd, that the thalami are concerned in the upward transmission and elaboration of sensory impulses, in contradistinction to the corpora striata, which are concerned in the downward transmission and elaboration of motor impulses, seems to be gaining ground, and many facts may be urged in its favor.

When the cerebrum is removed from some animals, the frog in particular, the basal ganglia being left intact, and some outward excitation be afterward used to induce movement in the animal so mutilated, there is every indication *that the animal can see*, because it avoids objects placed before the eyes, in case they tend to obstruct its passage.[1]

[1] Such an animal will even try to avoid *strong shadows* thrown by the sunlight across its path.

Its movements are those of an entire frog, except that they require some external stimulus to call them forth. It can be made to crawl, jump, croak, swim, and perform all other acts of an automatic machine. It is the effect of light upon its movements, however, that has some bearing upon the existence of a *visual centre* within the substance of the thalamus, since no observer has ever demonstrated that the corpus striatum is related either anatomically or physiologically with that sense.

THE CENTRAL TUBULAR GRAY MATTER.

The prolongation of the gray matter of the spinal cord, which lines the third ventricle, is best described in connection with the thalamus, although it is structurally independent of that ganglion. The following parts have been definitely made out:

1. The *inferior optic ganglion.* This mass of gray matter is situated at the lateral border of the tuber cinereum. Meynert and Luys describe it as forming an integral part of the tuber cinereum, although Wagner considers it as a part of the anterior perforated lamina. It presents a distinct sickle-shaped outline on longitudinal sections, the concavity of which looks forward. Luys thinks that the two ganglia join in the median line, and that the fibres of the optic nerve decussate within them. The opinion of Meynert is directly opposed to this view. This author advances, moreover, some anatomical grounds for the belief that the fibres of the optic tract really belong to the superior projection system (analogous to the "radiating fibres" of the cerebrum); that the inferior optic ganglion is to be regarded as the peripheral extremity of these fibres; and, finally, he suggests that in some undiscovered way the fibres will probably be traced later to some nucleus of the central tubular gray matter intimately connected with some other part

of the body, perhaps the muscles of the eye. If this view be accepted, the superimposed layers of the retina must be considered as analogous to those found in the cortex cerebri.

2. Within the tuber cinereum, behind the inferior optic ganglion, *commissural fibres* which turn backward within the central tubular gray matter may be demonstrated. The termination of these fibres is, as yet, unsettled.

3. The *posterior longitudinal fasciculus* of the tegmentum cruris may be traced along the central tubular gray matter of the third ventricle, the aqueduct of Sylvius, and the fourth ventricle. It terminates centrally in the broad, thin ganglion within the "substantia innominata of Reil." [1]

From this ganglion fibres may be traced into the "external capsule" of the cerebrum, the cortex of the operculum, the fossa of Sylvius, the island of Reil, the claustrum, and cortex of the temporo-sphenoidal lobe. The greater mass of the posterior longitudinal fasciculus of the tegmentum lies to the outer side of the anterior pillar of the fornix, but a few fibres from the "infundibulum" pass across the inner side of the pillar.

4. The *descending branch* of the *anterior pillar of the fornix* lies within the central tubular gray matter of the third ventricle. The *ascending branch* is also similarly embedded before it enters the body of the thalamus, and the same may be said of the *upper part of the corpus candicans* (mamillary tubercle). Luys, Arnold, and Meckel believe that the descending branch of the crus of the fornix becomes fused with the stria cornea, and the habenula conarii. The crus of the fornix makes a remarkable twist upon itself, the loop of which forms the corpus candicans (mamillary tubercle), when it reaches the base of the brain, and returns to enter the substance of the thalamus (bundle of Vicq d' Azyr).[2]

[1] The reader is referred to a previous page.

[2] Forel and Gudden deny that the fibres of the anterior pillars of the fornix are directly continuous with those of the bundle of Vicq d' Azyr.

It must not be inferred, however, that the corpus candicans consists only of fibres of the fornix, doubled upon themselves ; as nerve-cells are abundant within it, some of which are in intimate relation with the fibres of the crus fornicis.

It will be apparent to you all, after what has been said, that the lining of the third ventricle represents a prolonga-

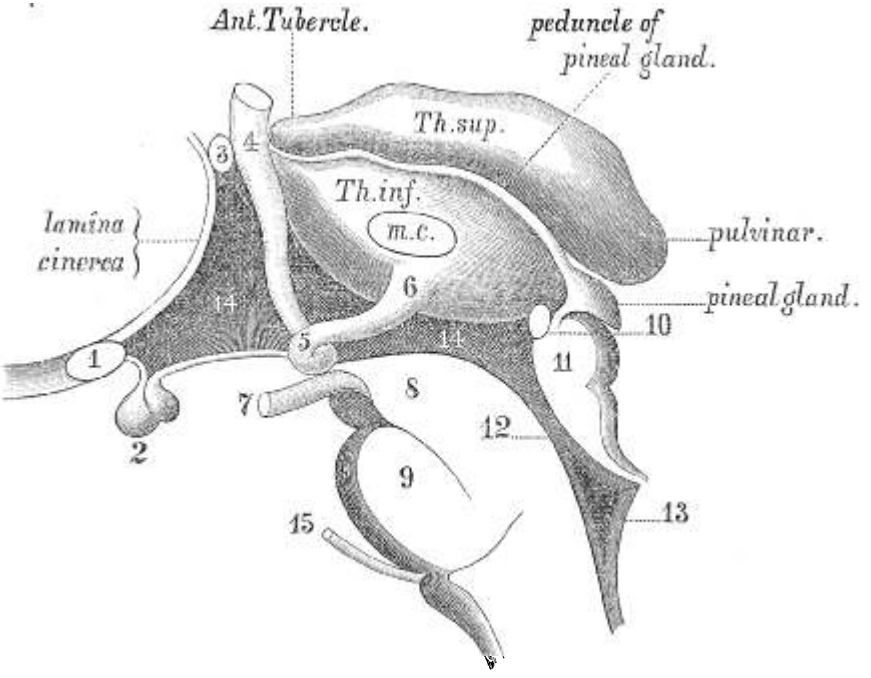

FIG. 5.—A DIAGRAM OF THE INNER SURFACE OF THE OPTIC THALAMUS, WITH THE TUBULAR GRAY MATTER REMOVED, SHOWING THE THIRD VENTRICLE, AND THE ARRANGEMENT OF NEIGHBORING PARTS. *Th. sup.*, superior part of thalamus ; *Th. inf.*, inferior part of same ; *m. c.*, middle commissure ; 1, section of optic commissure ; 2, infundibulum and pituitary body ; 3, anterior commissure of third ventricle ; 4, anterior crus of fornix ; 5, corpus candicans (mamillary tubercle) ; 6, bundle of Vicq d' Azyr ; 7, the third nerve ; 8, crus cerebri ; 9, pons Varolii ; 10, posterior commissure ; 11, corpora quadrigemina ; 12, aqueduct of Sylvius ; 13, fourth ventricle ; 14, third ventricle. This cut should be compared with Fig. 3, in which the gray lining of the ventricle is intact.

tion of the gray substance of the spinal cord into the brain. By Luys it is considered as connected with fibres embedded both within it and the thalamus, which concentrate themselves around certain nodal points, among which he men-

tions the "gray protuberances of the septum, for the olfactory roots; those of the tuber cinereum, for the optic fibres; the mamillary tubercles and pineal gland, for the connecting fibres emanating from the anterior centres." He also says: "It similarly receives a certain contingent of gray ascending fibres, which probably represent the centripetal spinal fibres which are distributed to these plexuses."

It is probable, and by some authors stated to be demonstrable, that all of the cerebral fibres, apparently distributed to the substance of the thalamus, are not connected with the nerve-cells of that ganglion. Some unquestionably pass *through* it to become united with the gray masses described as connected with the lining tubular gray matter of the third ventricle. In this way the thalamus becomes indirectly associated with the gray substance of the spinal cord as well as with the sensory tracts comprised within the "tegmentum cruris." It is from this stand-point that Luys expresses himself as follows:

"From this double induction we are therefore led to consider the masses of gray matter usually described under the name of "optic thalami," as essentially central regions which are the bond of union between the various elements of the entire cerebral system.

"Through their tissues pass vibrations of all kinds—those which radiate from the external world, as well as those which emanate from vegetative life. There, in the midst of their cells, in the secret chambers of their peculiar activity, these vibrations are diffused, and make a preparatory halt; and thence they are darted out in all directions, in a new and already more *animalized* and more assimilable form, to afford food for the activity of the tissues of the cortical substance, which only live and work under the impulse of their stimulating excitement."